

## Based on the Patent Crop Breeding Development Tendency Analysis

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**Abstract.** Seed industry is the root to promote long-term stable agriculture development, and to ensure national food security. To make Beijing into a "city of the seed industry" and the seed science and technology innovation center, we need an objective analysis of the status of international seed industry technology development and breeding technology R & D priorities to plan the future development of seed industry and deploy the technology research and development direction. In this paper, in order to get analysis and research on the patent in the field of crop breeding, we use patent retrieval tools such as TI, TDA, Innography and other patent search, analysis tools, we retrieves, analyzes and organizes the patents concerning crop breeding. Besides, the paper also studies the topics such as the variation trend, core countries or regions, core patent owners, technology distribution, and research hotspot of patent applications in the field. Finally, it discloses the overall patent layout and technical development trend of crop breeding and compares the strengths of various domestic and international organizations in the field, accomplishing the complete analytic report of the patent development trend in crop breeding. The report aims to provide reference to the agricultural scientific research as well as government decision-making.

### 1 Introduction

So far, it has been nearly 100 years since the rise of crop breeding industry. With the technological development, especially the technological development and application of plant hybrid and transgene, many high-yield and high-quality improved varieties have been cultivated in crop breeding field. Now, large scale seed industry has formed gradually. At present, crop seed industry has completed industrialization, modernization and internationalization process and entered the industrial monopoly stage of globalized development of seed industry led by high and new technology and driven by merging and reorganization.

From the development trend of crop breeding technology, the transgenic technology is controversy, but many current researches point out, such technology provides new alternative method to cope with challenges such as antagonism, environmental degradation, climatic change and provides opportunities and possibilities for the agricultural development in the future; traditional breeding mode and position is irreplaceable; rapid development of molecular biology modifies traditional breeding mode. New technologies such as molecular marker assisted selection, whole genome selection and the edition of peculiar locus genome provide infinite possibilities to the seed industrial development in the future.

### 2 Data source and analysis method

Patent technology is one of core foundations of competitive advantage among countries, regions, enterprises or industries. The research takes TI (Thomson Innovation) database as the data source to analyze related patents in crop breeding field. It obtained 19822 related patents in crop breeding field through retrieval (the retrieval date was July 20, 2015). By utilizing TDA (Thomson Data Analyzer), the paper makes statistics and analysis of general trend of patent in crop breeding field from the annual change trend of patent application quantity, major patent application country/region, major

application institutions and technological layout, and judges and analyzes technological R&D topic in related fields by combining with the contents of patent.

### 3 Analysis on annual trend of patent

The analysis is done based on the patent notification time. Through analyzing the patent notification year in crop breeding field, the paper gets the annual distribution situation of patent (Fig. 1).

Through analyzing the publicity year of 29822 crop breeding patent, it can be seen the patent application quantity in crop breeding field in recent 50 years ascends year by year. It can be divided into three stages:

Technological germination stage: from 1966 to 1987, there were a few patents applied in crop breeding field. The patent application was in technological germination stage and developing slowly. The patent quantity each year didn't exceed 100 pieces;

Technological growth period: from 1988 to 2004, the quantity of patent in crop breeding field appeared screw type growth trend. It had rapid growth stage as well as quantity fall year;

Technological development period: after 2005, the quantity of patent in crop breeding field grows rapidly and the average growth reached 13.5%. The patent application quantity in recent three years accounted for 30% of total quantity of patent applied in such field. It can be seen that the research in this field is in a very active state (because of time lag, the data in 2014 is only for information)

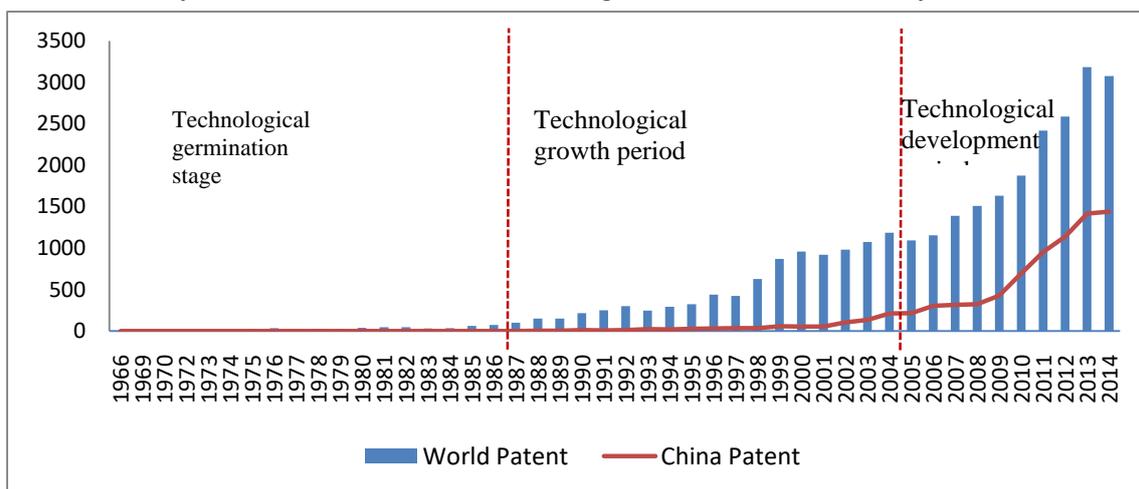


Fig. 1 Annual change trend of patent in crop breeding field

### 4 Analysis of major countries/regions applying for patent

#### 4.1 Analysis on major institutions accepting patent application

The research analyzes the country/region distribution of patent in this field from the transition of country applying for the patent in this field in recent 50 years, the distribution situation of patent in this area in each country/region in recent years and the growth situation of the patent in this field in each country/region in recent three years.

##### 50 years' development and transition

for the early 20 years from 1966 to 1985, the former Soviet Union ranked the first place in the world with 180 patents, Romania ranked the second place with 69 patents, followed with the US, EU and France, while China lacked patent application system and was blank in the patent record of this year. For 10 years from 1986 to 1996, the former Soviet Union ranked the first place in the world with 392 patents, Hungary ranked the second place with 382 patents, followed with World Intellectual Property Office, US, Japan, and China ranked the seventh place with 109 patents. From 1996 to 2005, the quantity of patent application in this field grew dramatically, ranking the first place with 2934 patents. Meanwhile, China also had great progress in such field, ranking the third place with 932

patents. Until these ten recent years from 2006 to 2014, China ranked the second place with 7226 patents, only second to the US with 7399 patents. It became the patent application power in this field.

*Development situation in recent 10 years*

from 2005 to 2014, the top 10 institutions accepting crop breeding patent application are US Patent and Trademark Office (US), State Intellectual Property Office of People’s Republic of China (CN), World Intellectual Property Organization (WO), Korean Patent Office (KR), Japanese Patent Office (JP), Canadian Patent Office (CA), European Patent Office (EP), Russian Patent Office (RU), French Patent Office and Indian Patent Office (IN) . The sum of patent application quantity accepted by the above institutions accounts for over 97% (Fig. 2).

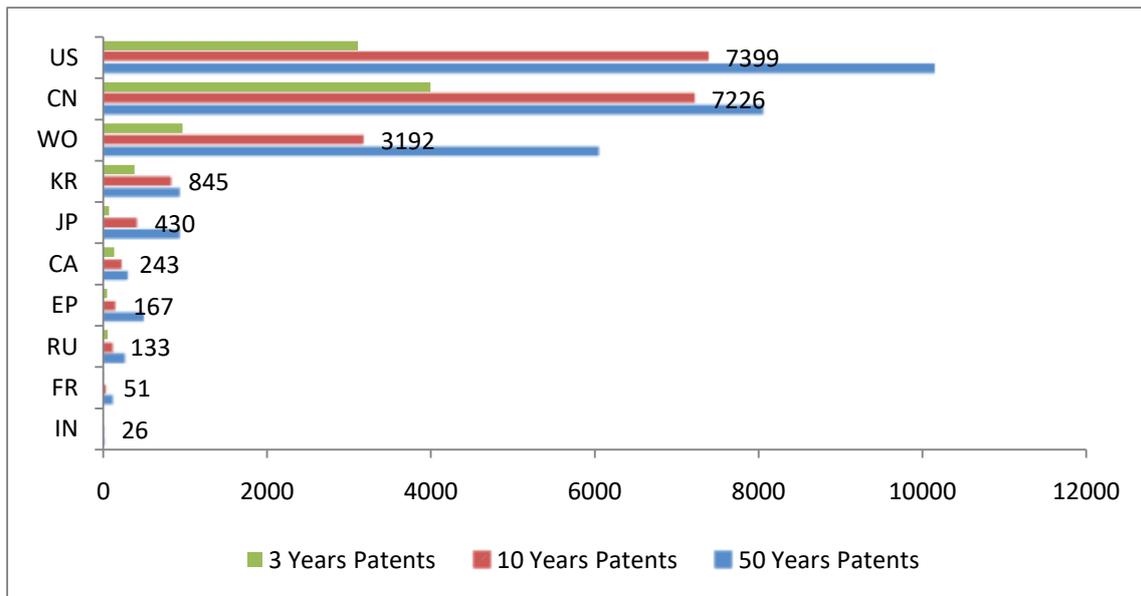


Fig. 2 Major countries/regions accepting patent application in crop breeding field

*Development trend in recent three years*

through comparing the proportion of patent quantity of TOP 10 patent application country in recent three years in total quantity in recent 10 years, it can be seen the patent quantity of China in recent three years accounts for 55.3% of the total quantity in recent 10 years, with highest proportion in these 10 countries; Canada ranks the second place with the percentage of 54.3%. It also grows rapidly in this field; Korea, the US and Russia ranks the third place, the fourth place and the fifth place with 45.2%, 42% and 40.6%. It reflects that these five countries are active in crop breeding research field in recent three years (Table 1). Generally speaking, American growth slows down, Chinese development becomes strong and the prosperous development times of Chinese crop breeding research is coming.

Table 1 the proportion of patent quantity in TOP 10 countries/regions with the quantity of patent in crop breeding research in recent three years in total quantity of patent in recent 10 years

Countries/regions	Patent quantity/piece	Quantity/piece of patents in recent three years	Percentage of patent in recent three years in total quantity of patent in recent 10 years
USA	7399	3110	42.0
China	7226	3995	55.3
World Intellectual Property Office	3192	967	30.3
Korea	845	382	45.2
Japan	430	69	16.0
Canada	243	132	54.3
EU	167	49	29.3
Russia	133	54	40.6
France	51	7	13.8
India	26	3	11.5

#### 4.2 Analysis on relative influence of major countries/regions

In order to analyze the relative influence of countries/regions from quantity and quality of patent in this field, the research constructs relative influence analysis method based on patent information attribute. As is shown in the graph: according to the relative location distribution diagram (Fig. 3) of the patent quantity and cited number of chapter in major countries/regions, it can be seen that, in crop breeding research, the US is in the first quadrant, whose patent quantity and cited number of chapter are higher than the mean, belonging to double high (high quantity of patent and high number of cited chapter) country/region, so it is in technological leading status in this field; Germany is located in the fourth quadrant, whose patent quantity and cited number of chapter are lower than the mean. The relative quantity of patent is limited, but the patent influence is high, belonging to technological strength school. China is in the second quadrant, whose patent quantity is higher than the mean and the cited number of chapter is lower than the mean. The research scale is big, but the influence is relatively weak. It indicates that it is active in technological research and has the development potential. Korea, Japan, Russia, Canada, France, India and Australia are in the third quadrant, whose patent quantity and the cited number of chapter are lower than the mean, belonging to double low (low quantity of patent and cited number of chapter) country. The research scale and influence are relatively weak.

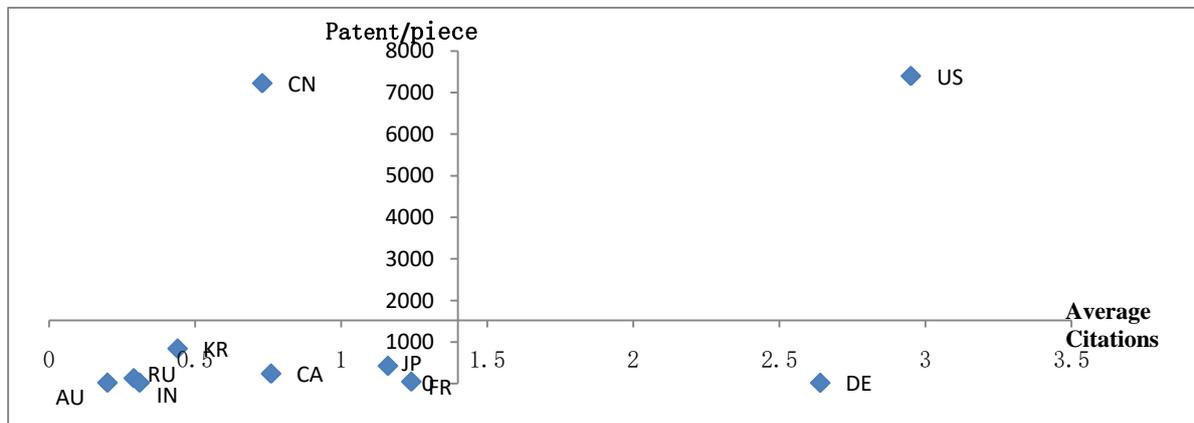


Fig. 3 Relative position distribution diagram of the cited quantity and pieces of patents in major countries/regions working on crop breeding research

### 5 Analysis of major patentees

#### 5.1 Distribution situation of major patentees

From the distribution situation of patentee, TOP 15 institutions with patent application quantity in crop breeding area are Monsanto Technology LLC, Pioneer Hi-Bred Int Inc, Syngenta Participations AG, Chinese Academy of Agricultural Sciences, Chinese Academy of Sciences, Stine Seed Company, Basf Plant Science GmbH, Nanjing Agricultural University, Huazhong Agricultural University, Dow Agrosciences LLC, Bayer Cropscience Ag, Jiangsu Agricultural Science Institution, China Agricultural University, Korea Rural Development Administration and Zhejiang University (Table 2). Among these 15 institutions, there are seven Chinese institutions, four American institutions, two German institutions, one Swiss institution and one Korean institution. From the nature of institution, it can be seen international enterprise accounts for big proportion. It also indicates that international enterprise has outstanding contribution to the research and industrialization of crop breeding, while the leading Chinese institutions in the patent quantity of this filed are mostly research institutions and colleges.

**Table 2 Top 15 Institutions with the quantity of patent application in crop breeding field**

<b>Rank</b>	<b>Patentee</b>	<b>Countries/regions</b>	<b>Nature of institution</b>	<b>Quantity of patent</b>
1	Monsanto Technology LLC	US	Enterprise	2792
2	Pioneer Hi-Bred Int Inc	US	Enterprise	2757
3	Syngenta Participations AG	Switzerland	Enterprise	582
4	Chinese Academy of Agricultural Sciences	China	Research institution	575
5	Chinese Academy of Sciences	China	Research institution	557
6	Stine Seed Company	US	Enterprise	439
7	Basf Plant Science GmbH	Germany	Enterprise	333
8	Nanjing Agricultural University	China	College	287
9	Huazhong Agricultural University	China	College	249
10	Dow Agrosciences LLC	US	Enterprise	228
11	Bayer Cropscience Ag	Germany	Enterprise	210
12	Jiangsu Agricultural Science Institution	China	Scientific research institution	200
13	China Agricultural University	China	College	200
14	Korea Rural Development Administration	Korea	Research institution	198
15	Zhejiang University	China	College	187

## 5.2 Analysis on relative affluence of major patentees

Patent application quantity can indicate the intellectual property status of patentee in the field, but it cannot indicate its technological status and level in this field. The combination of patent quantity analysis and quotation analysis of patent is able to show the relative influence of patentee in such field.

Taking the patent quantity of major patentee and cited number of chapter in crop breeding field as the y and x coordinate (Fig. 4), the paper analyzes the research scale and influence. It can be seen, Monsanto Technology LLC belongs to double high institutions with high patent application quantity and high cited number of chapter, which is industrial leading enterprise; Stine Seed Company, Dow Agrosciences LLC and Basf Plant Science GmbH are in the fourth quadrant, whose patent application quantity are is lower than the mean and the cited number of chapter is higher than the mean. These three institutions have the relatively limited patent application quantity, but they have higher patent influence and thus they are the technological strength school in such field; Pioneer Hi-Bred Int Inc is in the third quadrant, whose patent application quantity is higher than the mean, but the cited number of chapter is slightly lower than the mean. It can be seen it has high research activeness and great development potential; the other five institutions including Syngenta Participations AG, Chinese Academy of Agricultural Sciences, Chinese Academy of Sciences, Nanjing Agricultural University and Huazhong Agricultural University belong to double low (low patent application quantity and low number of cited chapter) institutions. The research scale and influence are relatively weak, and the strength is weak compared with other institutions.

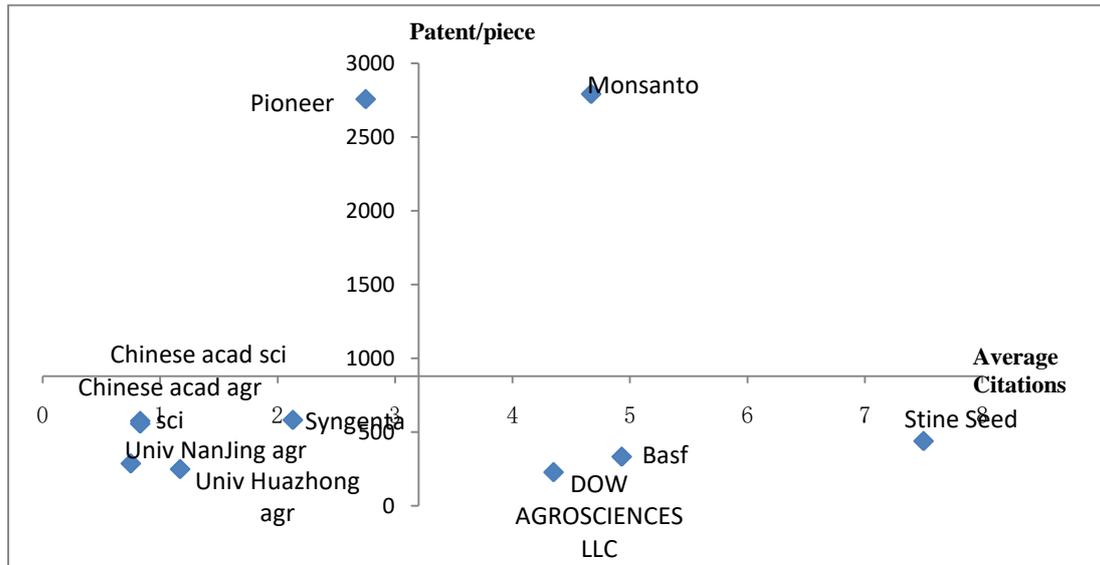


Fig. 4 Relative position distribution diagram of the cited quantity and pieces of patents owned by major patentee working on crop breeding research

### 5.3 Analysis of patent strategic layout of major patentees

Fig. 5 is the global distribution situation of patent of major patentee in crop breeding field. Each color represents an institution, the x coordinate represents the patent applied by some country/region and the bubble size indicates the quantity of patent application. According to the diagram, it can be seen Monsanto Technology LLC and Pioneer Hi-Bred Int Inc are the major patent application institution in this field. They mainly apply for patent in the US, as well as focus on the patent layout in foreign market, so they apply for patent positively in China, Canada, Australia, India and Mexico, etc. From the whole, barring Stine Seed Company only applies for patent in the US, international enterprises focus on patent layout in various countries of the world, while Chinese research institutions and colleges are weak in foreign patent layout. It needs to strengthen strategic layout in the foreign market at the time of protecting domestic market.

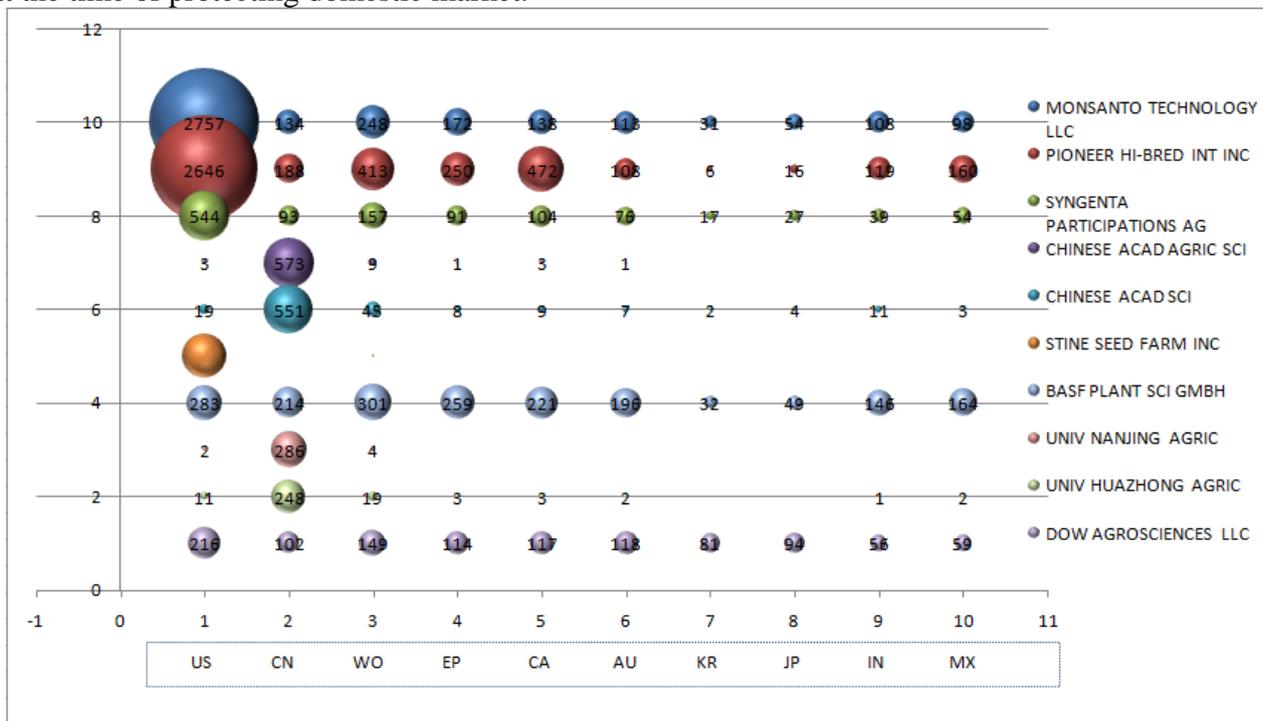


Fig. 5 Patent strategic layout of Top 10 patentees in each countries/regions

### 5.4 Analysis of cooperative relationship of major patentees

From the partnership diagram of TOP 15 institutions with patent application quantity in crop breeding field (Fig. 6), it can be seen institutions tend to cooperate with the institutions of their own countries, and there is a little transnational cooperation among institutions.

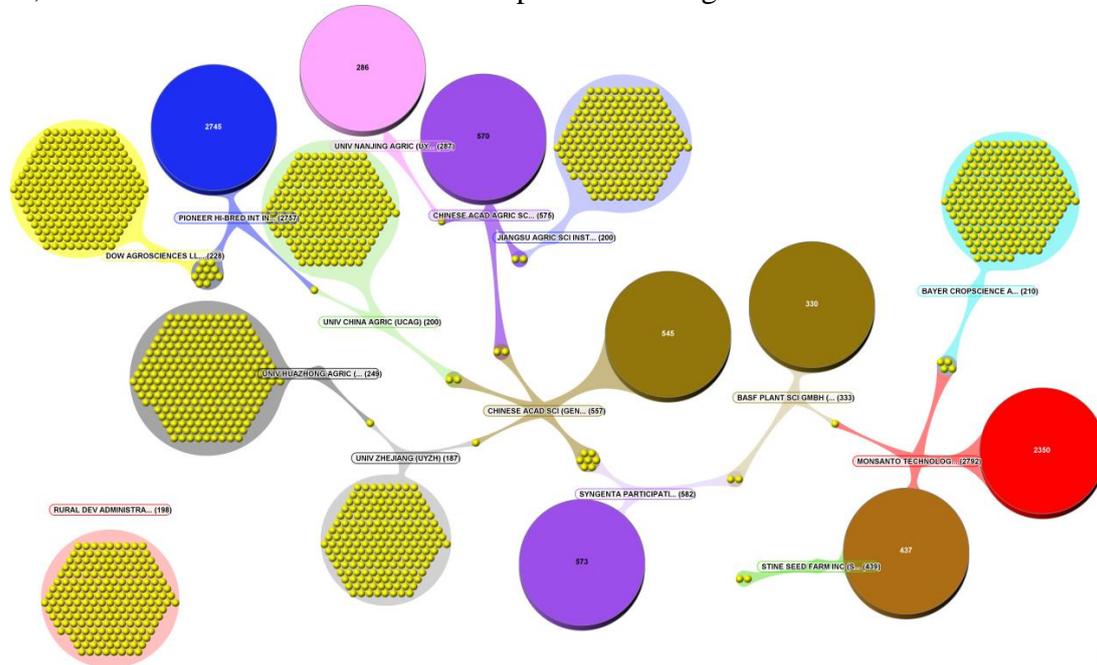


Fig. 6 The application situation of major institutions in crop breeding field for patent cooperation

## 6 Conclusion and prospects

### 6.1. The quantity of patent application in crop breeding field shows ascending trend year by year and enters rapid development stage in recent 10 years.

The development of crop breeding field in recent 50 years can be divided into germination stage, growth stage and development stage: from 1966 to 1987, there were a few patents applied in this field and patent application in such field developed slowly; from 1988 to 2004, it appeared screw ascending development trend; since 2005, the patent quantity in crop breeding field grew rapidly and entered rapid development stage. The average annual increasing reached 13.5% and the patent application quantity in this field in recent three years accounted for 30% of total quantity of patent application. It can be seen the research in this field is very active and it will show rapid growth trend in a while.

### 6.2. As the major patent application countries, the US and China has the quantity of patent application far exceeding other countries. In recent 10 years, the growth of US slows down, but China has a strong development momentum.

Patent application countries/regions in crop breeding field changes constantly. In recent 10 years, the countries accepting most patents in such field are the US and China. The accepted quantity of patents has exceeded other countries/regions. The quantity of patent in China in recent three years accounts for 55.3% of total quantity of patents in recent 10 years. It has the highest percentage in TOP 10 countries with patent application quantity. It reflects China is very active in the research on crop breeding field and has strong development. The growth has exceeded that of the US. The prosperous development times of Chinese crop breeding research is coming. In relative influence of patent, American patent quantity and the cited number of chapter are higher than the mean and in a technological leading status. Germany belongs to technological strength school, worth to be paid

attention. Chinese research scale is bigger, but the influence is weak, and it has development potential.

**6.3. The proportion of international enterprises in major patentee of crop breeding field is bigger and international enterprise focuses on international strategic layout. Patentees tend to cooperate with the institutions of its own counties and there is a little transnational cooperation among institutions.**

International enterprises account for big proportion among patentees doing great contribution to world crop breeding field. It reflects the contribution of international enterprises in the research and industrial process of crop breeding, while research institutions and colleges in China rank the forefront in the quantity of patent in this field. Among TOP 10 patentees, Monsanto Technology LLC is an industrial leading enterprise high institutions with high patent application quantity and high cited number of chapter; Stine Seed Company, Dow Agrosiences LLC and Basf Plant Science GmbH have the relatively limited patent application quantity, but they have higher patent influence and thus they are the technological strength school in such field; Pioneer Hi-Bred Int Inc has high research activeness and great development potential; Syngenta Participations AG, Chinese Academy of Agricultural Sciences, Chinese Academy of Sciences, Nanjing Agricultural University and Huazhong Agricultural University are weak in strength compared with other institutions. In patent strategic layout, Monsanto Technology LLC and Pioneer Hi-Bred Int Inc are the major patent application institution in this field. They mainly apply for patent in the US, as well as focus on the patent layout in foreign market. From the whole, barring Stine Seed Company only applies for patent in the US, international enterprises focus on patent layout in various countries of the world, while Chinese research institutions and colleges are weak in foreign patent layout. It needs to strengthen strategic layout in the foreign market at the time of protecting domestic market. And, the institutions tend to cooperate with the institutions of their own countries, and there is a little transnational cooperation among institutions.

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